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THE DESIGN OF INSTRUCTIONAL EQUIPMENT--TWO VIEWS.

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THE STUDY PRESENTED IN THIS REPORT WAS COMMISSIONED BY THE TECHNOLOGICAL DEVELOPMENT PROJECT OF THE NATIONAL EDUCATION ASSOCIATION. INCLUDED IN THE STUDY ARE TWO PAPERS CONCERNED WITH THE PROBLEM OF DESIGNING INSTRUCTIONAL EQUIPMENT. THE TWO AUTHORS (FROM EQUIPMENT MANUFACTURING FIRMS) WERE ASKED INDEPENDENTLY TO WRITE UPON THESE QUESTIONS--(1) HOW HAS INSTRUCTIONAL EQUIPMENT BEEN DESIGNED IN THE PAST, AND (2) HOW SHOULD IT BE DESIGNED IN THE FUTURE. EACH AUTHOR TREATED THE PROBLEM DIFFERENTLY. HUMBOLT W. LEVERENZ DEALT PRIMARILY WITH DESIGN ITSELF, WHILE MALCOLM G. TOWNSLEY DISCUSSED PROBLEMS ASSOCIATED WITH ECONOMICS AND ORGANIZATION OF THE DESIGN PROCESS. A BIBLIOGRAPHY IS INCLUDED WHICH IS RELATED TO PSYCHOLOGICAL PRINCIPLES INVOLVED IN THE DESIGN OF TRAINING EQUIPMENT. (JC)

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Humboldt W. Leverenz and
Malcolm G. Townsley

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A Report Prepared for the

TECHNOLOGICAL DEVELOPMENT PROJECT

of the

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FOREWORD

The Technological Development Project is attempting to assess the impact of the potential technological revolution of the sixties--a revolution in the way in which young people and adults will learn and be taught--upon the American system of education and the educational profession. We grant that this high sounding objective may be impossible of achievement. However, the processes of the introduction of all phases of technology into the educational system continue apace and the attempt must be made.

The general method of attack on this problem has been to conduct a wide ranging program of studies over a large area. This area has included such diverse segments as industrial developments of the recent past, the present and the future, educational theory and experiment, economics, organization, and such elusive topics as the problem of innovation. Some of the studies have been done by the staff; others have been commissioned.

The study presented in this paper is one of those commissioned by the Project. We were exceedingly fortunate in obtaining the consent of H. W. Leverenz, Associate Director, David Sarnoff Research Center, Radio Corporation of America Laboratories, and Malcolm Townsley, Vice-president, Photo

Products Division - Professional, Bell and Howell Company, to do these studies for us. Both men, in addition to being engineer-scientists, are top-flight administrators. As such, they are extremely busy. Yet both of them agreed to do these studies because of their intense interest in education. The Project Staff and its sponsoring bodies are extremely grateful.

I would also like to acknowledge the editorial assistance of Robert Heinich and the help of Seth Spaulding who reviewed the manuscript, Anna L. Hyer and Robert C. Snider of the Department of Audiovisual Instruction who made its publication possible, and Donald G. Perrin.

James D. Finn
Los Angeles, December 1962

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INTRODUCTION TO THE PAPERS

by
James D. Finn
Principal Investigator
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> The essential qualities of nature--life and movement, and time (the dimension in which they both occur)--are precisely the qualities which geometry cannot describe.
>
> ...Our obsession with pure geometry, in other words, leads us to make...a sort of Procrustean template which falls like a murderous cookie cutter across those living processes which do not happen to conform to its outlines.
>
> James Marston Fitch

Fitch was speaking of architecture in the quotation cited above, but the concept applies to much of the design modern man has to live with--his automobile, his can-opener, his bed. Design problems of several types--aesthetic, functional, reliability--have also plagued the users of instructional equipment--the classroom teacher and her students--since someone first figured out how to fasten a printed alphabet to a paddle and cover it with a piece of transparent horn to make a hornbook. Bad design has shown up in textbooks, in overweight projectors and in classrooms where sun-worshipping architects and administrators forgot about light control.

On the other hand, it is interesting that the word, "design," rarely appears in educational literature. When

it does, it is generally badly used as, "to design a curriculum," where the prescriptions suggested are not remotely related to the principles of design. In the one hundred and fifty years or so that the American teacher and professor have been using equipment of one kind or another in the teaching process, there has been little public indication that teachers and professors, as professionals, are greatly concerned with the design of this equipment.

And yet, they are concerned. One only has to listen to teachers talk about their problems. An old, and somewhat grim joke in the audio-visual field refers to the 110 pound school teacher who has to carry a 40 pound projector up to the third floor to show a film in a room with no provision for light control. Such stories come out of the remarks teachers make in the faculty lounge, in the reasons they give for not being more enthusiastic about the new technology of instruction and in the records of use of existing audio-visual materials and devices.

Incidentally, the new instructional equipment is not immune. The advent of the teaching machine, the language laboratory and even television has broadened the scope of the design problem, but has not yet shown the way to its solution.

For example, simple, Skinner, write-in teaching machines have been torn apart by sixth-graders--by use, not by mischief or malice; useless microphones, pieces or earphones and red-lined tape decks dot the landscape of the language laboratory field; classroom television receivers have been mounted on high racks so tippable that it is a great wonder that many young viewers have not perished in an electronic landslide.

The examples cited are really simple design problems which have to do with safety and reliability. Reliability and safety are ancient, respected engineering functions. If these have, in many cases, not been incorporated into the design of classroom equipment, old or new, what about other, more complex functions? Again, many cases can be cited where audio response, projected visibility or overall functioning of a piece or set of teaching equipment have not been satisfactory.

The design problem when seen in this perspective is a problem of some magnitude. <u>There is no reason to expect a technological revolution in education when the machine portion of the man-machine system cannot deliver due to faulty or careless design</u>. In more simple terms, many

teachers will not use films, tapes, slides or filmstrips if it is mechanically difficult to use them, valuable as they may be in the teaching situation; a school district will not purchase many teaching machines (or, for that matter, programed textbooks) if they fall apart; repaid bills for television sets (not to mention the size and quality of the picture) can discourage even a TV enthusiast.

What are some of the dimensions of the problem of designing instructional equipment? As I see it, there are at least three. These are: (1) human factors, (2) economic factors (and organizational), and (3) attitudinal factors.

The great industrial designer, Henry Dreyfuss, has written a fascinating book entitled, Designing for People. The title, obviously, carries his basic philosophy. Since education is a distinctive human enterprise involving, principals, teachers and students, the instructional equipment used in the process ought to be designed for educational people. Students ought to be able to see, hear and manipulate with ease and at proper levels for the task at hand. Teachers should be able to maneuver, adjust and otherwise control the equipment easily and rapidly. The equipment, itself, should be able to fit properly into the human factors relating to the teaching-learning task.

It may be objected that the preceding paragraph belabors the obvious. Such a view is extremely naive. The fact is that most instructional equipment in use today does not meet these general requirements and has, actually, not been designed for educational people.

The second dimension--economics and organization--explains, at least in part, the first. As will be seen from the following papers, equipment used in schools is generally designed and built for another job and, later, adapted to school use. This is a function of educational economics which simply has not been able to provide the financial return necessary in a short enough time to enable the producer of equipment to stay in business when he relies upon the educational market alone. Manufacturers have stayed in the educational business by designing their products for other or multiple uses and by using old design concepts not necessarily related to existing instructional problems and current technology, because research and development cannot pay out in anything like a reasonable time. Hence, the educational human factors--designing for educational people--have been more or less ignored in the creation of instructional equipment. Teachers and students have too often been subjected to the "murderous cookie cutter" as the

living process of instruction is cut by the geometry of engineering and economics.

This situation, however, is interrelated with another--the nature of the educational organization in the United States. Local control of schools and even state control is not necessarily a good basis from which to present an attractive market to the manufacturer. Stop frames on motion picture projectors may be specified in Los Angeles and prohibited in New York; grounded plugs may be required in Indiana and not in Georgia; a system of bidding useful in purchasing toilet paper in St. Louis may well be a hindrance in the purchase of television sets in Montgomery County, Maryland. The organization of the American school system presents many obstacles to the potential designer of instructional equipment. I have suggested only a few.

The first two dimensions--human factors and economics and organization--are difficult enough to overcome. The third attitudinal factors, aggravates the design situation even more. By attitudinal factors, I mean the attitudes of people concerned in the instructional process. While there are many such people in both the industrial and the educational systems, I will only mention two groups as examples--teachers and educational administrators.

A good case can be made that the American teacher (and professor) simply does not, due to training and experience, think in patterns which would be helpful in improving the design of instructional equipment. Naturally, there are all kinds of exceptions to this statement, but the generalization appears to be true in the main. Whereas the carpenter, the automobile worker, the dentist and the laboratory scientist traditionally have an orientation toward the technology of their craft or profession which puts a premium on the improvement of design, the teacher does not. Teachers are ingenious in inventing, adapting, changing and improving <u>methods</u>, but they do not have the same attitude toward the equipment they use. They recognize its weaknesses, but rarely, if ever, in the history of American education has the profession--or even significant groups of professionals--risen up and demanded changes in design or new designs for equipment. Had this occurred, the market situation described above would have changed and industry would probably have responded. Up to this point in time the general attitude which would point thinking and acting in the direction of better design has

not been present in the teaching profession.[1]

What has been said of the teacher can also be said of the administrator. The major cliche of educational administration is that the administrator's only excuse for being is that he is there to help expedite and improve instruction. However, the record shows that, at no time, have administrators pushed vigorously for the improvement of design in instructional equipment. In other school equipment areas, administrators have made themselves felt. School busses throughout the United States are painted organge--an important safety design factor that can be credited to educational administrators. Administrators cannot claim such credit in the field of instruction.

At the operational level, the key figure in the instructional equipment picture is, too often, the school or college business official. Such officials are bound, of course, by

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[1]A possible explanation of the reason for this missing attitude may be found in the concept of the technological milieu in:

Finn, James D., Donald G. Perrin and Lee E. Campion, Studies in the Growth of Instructional Technology, I: Audio-Visual Instrumentation for Instruction in the Public Schools, 1930-1960--A Basis for Take-Off, Occasional Paper #6, Technological Development Project, published by the Department of Audiovisual Instruction, NEA, Washington, D. C., p. 4 and p. 9.

regulations concerning bidding, etc. However, when such an official amounts to the "gatekeeper" in the purchase of instructional equipment, considerations of design other than reliability are likely to go by the board. There have been many instances where even reliability has given way to price. When this happens throughout a market, design suffers and, consequently, the user suffers.

The previous few pages provide only a cursory survey of the problem of the design of instructional equipment. Because this problem has increasingly come to the fore in any examination of the potential technological revolution which many think will invade education in the sixties, we decided to obtain some fresh views of the problem from two very knowledgeable men.

In the pages that follow will be found two papers. One is by H. W. Leverenz of the Radio Corporation of America and the other by Malcolm Townsley of the Bell and Howell Company. Both men are eminently qualified to comment on this problem of the design of instructional equipment. In discussing their assignment, they were each asked independently to write upon two questions: how has instructional equipment been designed in the past? and how should it be designed in the future?

As might be expected, each writer took his own view, not only of the answers, but of the questions as well. The result has been two excellent papers, each treating the problem in a different way. Leverenz deals primarily with the design process itself, while Townsley addresses himself more to the problems associated with economics and organization as they affect the design process. As it turned out, each paper compliments the other.

Since this publication treats only a portion of the rather large area of the design of instructional equipment, a special bibliography has been added. This bibliography is principally concerned with the research done in the Department of Defense relating to the psychological principles involved in the design of training equipment. To this we have added two books by Henry Dreyfuss and one by James Marston Fitch which are generally pertinent and the two well known and "must reading" essays by Robert Wagner which remind us that the principles of design do not end with equipment--that they do, indeed, extend into the area of materials as well.

THE DESIGN OF INSTRUCTIONAL EQUIPMENT: I

by

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Introduction

This paper emphasizes some of the basic human factors involved in the design of instructional equipment. The approach to the subject is rather unorthodox. It is an attempt to provide designers, teachers, and administrators with a common viewpoint, and hopefully a common resolve, toward a challenge that is their mutual concern. The challenge, in essence, is to form and maintain carefully selected teacher-designer (plus learner) teams. A common objective of those teams is to have their members apply their conjoined ingenuities and resources to the task of making significant improvements in the design and use of instructional equipment. It is envisioned that the improvements, for the benefit of learners and teachers, will appear and be introduced in evolutionary fashion. Those who contribute to that evolution deserve substantial and continuing support.

Having mentioned that emphasis is to be placed on human factors, it is apparent that several important words are missing in the assigned title of this paper. Three of them are the words "people," "learn," and "teach." Although these words are implied in the title, they deserve to be brought into better focus.

People and Culture

At the grass roots of our topic is the fact that people are born and die. They occur as discontinuous physical bits in the stream of time. The culture that they generate, however, persists. For our purposes, culture is a set of beneficial qualities that people do not inherit, but can learn; a set that persists, spreads, and grows as a relatively continuous social phenomenon.

Because each person is born devoid of culture, the forward movement of culture with time goes by fits and starts, when it is considered as a unit process. From the standpoint of the community, a new-born member appears with zero culture, then slowly acquires a substantial charge of culture to become much more acceptable and valuable in the community, and finally disappears, cultural charge and all. In sizable communities, people of all ages commingle, thereby facilitating

the passing on of culture as a generally smooth flow for the community at large.

Learning and Teaching

Communities are dynamic systems wherein different people appear and disappear in an on-going cultural environment. In such an environment it is obvious that a person should learn but, beyond the minimal learning needed for survival, it is not obvious that a person must learn. With complex and different individuals interacting in our complex society, the rewards (e.g., recognition, income, and satisfaction) for an individual are not always commensurate with what or how much he has learned. Where, then, is the incentive to learn?

One obvious and worthwhile incentive grows from a desire to emulate the satisfactory attainments of outstanding culture (well-educated) persons. Their examples are prime carrots to hold in front of insufficiently cultured 'donkeys.'

A strong, countervailing disincentive arises from the travail of learning. It is human to rebel against prolonged concentration, especially when the rewards are neither immediate nor certain. For the young, much of the necessary

sustaining force is supplied and applied by parents and teachers. It may be that professional teachers were invented by parents who got fed-up with the two-pronged chore of (1) attempting to teach, and (2) insisting that their children learn. Nonetheless, parents still do a lot of the teaching and insisting.

In terms of motivation and action, both learning and teaching are, basically, human processes. Learning is done by people <u>for</u> people. A person learns in order to please people, including himself. At worst, he does so to decrease the displeasure of someone of consequence to him. If he works at learning to operate a machine he does so to please some person, or persons, certainly not to please the machine. (If he claims that he does so to displease another person, then it is because it pleases him to cause another's displeasure.) He may even figure the thing out for himself. If so, the machine did not teach him, he taught himself. By so doing he becomes more pleased with himself, and his accomplishment and increase in self-confidence may be pleasing to others. An important function of the teacher (including the parent) is to express pleasure and displeasure as a representative of the community that wants its members to learn; that is, acquire culture.

Viewed grandly and fundamentally, teachers are expected to bring about and encourage

1) the repetitive passing on of culture from previous to present generasions,

2) the spreading of culture throughout mankind, and

3) the generation of new culture.

Expressing the teacher's total mission in a closer-to-home way, he is expected to help and persuade people to

1) learn and use culture that other people have originated,

2) become propagators of culture, and

3) become originators of culture.

Pinches, Grunts, and Smiles

In primitive society, people found by experimentation that certain actions were pleasing and others displeasing. A person might enjoy having a neighbor scratch his back, but take a very dim view of an attempt to carve a steak off of his haunch. The person usually reacted to express approval or disapproval. People's brains remembered these actions and reactions, with reinforcement provided by repetition. Culture had its beginnings in some such fashion, prompted by the desire of people to maximize the pleasant and minimize the unpleasant.

The early problem of conveying messages from one person to another was solved by using what I choose to call pinches, grunts, and smiles (or scowls). These mechanical, audio, and video means for communication are in universal and regular use today. They require no auxiliary equipment, and are probably as effective as ever, though only at short range.

Over the years, the brain has continued to be a remarkable, though faulty, means for storing messages; pinches and smiles have continued to be effective, though very limited in their message-carrying capacity, and grunts have evolved into an enormous variety of spoken words to become the workhorse of person-to-person communication. A human being, therefore, is able to perform all of the basic information-handling tasks that are required to pass-on culture. These basic tasks are that cultural messages be

1) stored (remembered),

2) transmitted (taught) to another person,

3) received (understood) by that person,

4) stored and used (learned) by that person.

These capabilities of people are marvelous, but they are inadequate for handling the burgeoning message traffic of culture. As noted, people are both faulty and limited in their ability

to store, transmit, and receive messages. Furthermore, death terminates the stored messages along with the ability to store, transmit, and receive.

Help Wanted

Message storage and communication were enormously improved when spoken words were coded as combinations of a few standardized symbols (letters and numbers) that could be easily and permanently printed, duplicated, and distributed. Thenceforth, a given message could be communicated either as a sequence of transitory audio (spoken) signals or as persistent video (printed) signals. The versatile brain gets essentially the same message from the two different kinds of signals and different means for receiving the signals.

The message-handling capacity of a human being is less than 40 signals (e.g., symbols) a second. That is, he can receive and understand a maximum of 40 signals a second if he is giving his full attention to the task. Thanks to the invention of printing, a person now can easily and quickly pick up a book containing 400,000 signals. While it is true that he can "receive" the book in less than a second, he must still spend at least 10,000 seconds (3 hours) to read and attempt to understand all of it. He can also

walk into the main library of a large university and have quick access to more than a million books and documents, but he'd have to spend more than three million hours (1,000 years of eight-hour days) to read them with thorough understanding.

It is obviously not possible for one person to acquire all of the available culture. Amidst so much that might be learned, a person needs a lot of help in order to get a substantial cultural charge within his allotted time. For maximum benefit to the community and the individual, there should be careful selection of cultural subject matter, and the mode and timing of its transmission, with a high degree of sensitivity to the aptitude and temperament of the particular learner. It has become common practice for parents, students, and the community to rely chiefly on professional teachers for much of the cultural decision-making during the critical early years that an individual is exposed to education.

An <u>ideal</u> teacher would presumably have

1) complete knowledge of all the available culture,

2) unerring ability to ascertain the aptitude and temperament of any individual,

3) flawless ability to select, organize, and transmit the most appropriate knowledge, quickly, in the manner and at

the time and pace best suited to the individual, and

4) foreknowledge of that individual's future.

A real teacher (or anyone else, for that matter) has

1) limited knowledge, usually specialized,

2) difficulty in ascertaining the innate aptitude and temperament of anyone,

3) difficulty in locating, selecting, organizing, and transmitting the knowledge that is most appropriate for a given person at a particular time, and

4) difficulty in envisioning the future of a given person.

Real teachers certainly need and deserve constructive help. Conversely, they should not get the kind of help that the elephant gave when he attempted to help the bird hatch the eggs.

Instructional Equipment

Real teachers have their native and acquired abilities to sense the needs of communities and learners, and to scoop out of their memory bins, and transmit by voice and demeanor that which seems appropriate at the time. For help, they now have a considerable arsenal of conventional video equipment, such as books, paper, pencils, pens, crayons, paints, brushes,

blackboards, and chalk. Most of this conventional equipment is so relatively new that it is still being modified and improved. The blackboard, for example, was not introduced into schools until after the beginning of the last century.

More recently, the teacher's natural audio equipment has been augmented by electronic public-address systems, record-players and records, tape recorder/players, and language laboratories; while the conventional video equipment has been increased to include periodicals, typewriters, teleprompters, programed textbooks, slide projectors, overhead projectors, film-strip projectors (some with sound tracks), movie projectors (with or without sound), television (usually including sound), and multifarious teaching machines. Also available are various mechanical drawing sets, slide rules, desk calculators, electronic computers, optical microscopes, electron microscopes, still cameras, movie cameras, binoculars, telescopes, musical instruments, athletic equipment, public libraries, art galleries, and museums.

Each of these items of equipment is a help in some kind of instruction. All of them together, however, are definitely too many and too complicated for any one teacher to master thoroughly enough to use with confidence and with the serenity

that induces receptiveness and confidence in learners. I suspect that most adults, including teachers, who have put in the time and effort required to learn how to walk, dress, tie shoelaces, talk, draw, read, write, operate home appliances, and drive automobiles get increasingly averse to working further mechanical complexities into their lives. It is no wonder, then, that teachers are warily selective in their acceptance and use of instructional equipment.

Design and Use

Given that (1) culture should be selected and imparted thoughtfully, yet rapidly, as a human-relations process conducted by teachers, (2) teachers need equipment to help them locate, organize, and communicate suitable culture quickly and effectively; yet there are already more kinds of instructional equipment than a teacher can handle, and (3) equipments are increasing in kinds and capabilities: chiefly because scientists and engineers are becoming increasingly proficient in synthesizing and utilizing new materials, phenomena, and technical concepts--what should be done about the design of instructional equipment?

Let's work this problem backwards by first looking into the manner in which scientists and engineers are getting

their equipment designed. To save ink and space, let's use the coined work "techniker" to denote a scientist or engineer.

It is traditional for technikers to design and use their own equipment. They do not expect non-technikers to design it for them. There is rather good coupling, often with person-to-person feed-back, between user and designer. Designers and users share the common objective of extending the capabilities of technikers by means of ingenious design and use of equipment.

While the output of major advances in equipment is accelerating, they still occur at unpredictable times, because major technical discoveries and inventions are not predictable. The following sequences are illustrative:

Seeing quick changes

The human eye cannot detect fluctuations in motion or illumination that are shorter than

one-tenth second

The mechanical-optical phosphoroscope (1854) displayed (to the eye) fluctuations as short as

one ten-thousandth second

The cathode-ray oscillograph (1890) has been made recently to display (to the eye) fluctuations shorter than

one one-billionth second

Seeing at a distance

Luminescence ("cold light") of phosphors (tiny crystals), excited by sunlight, discovered in 1603

Luminescence of phosphors excited by electrons (cathode rays) discovered in 1858

Cathode-ray tube, wherein an electron beam traces luminous patterns on a phosphor coating, invented in 1897

Television picture tubes (kinescopes) developed in 1930's

Television system, including home TV sets, made generally available in 1940's

In both sequences, one that greatly extended the capability of technikers, and the other that provided major new equipment for non-technikers as well as technikers, the designers and the users were technikers. The designers had a first-hand feel for what the users wanted, and could appraise the shortcomings of their equipment by personally using it. Thereupon, they could tackle the problem of minimizing the shortcomings in the order of their actual importance to the user.

Some of the problems that beset designers of instructional equipment are similar to those encountered in designing musical instruments. Woodwinds, such as clarinets,

oboes, and bassoons, are particularly difficult to design. In the past, major improvements in woodwind design, for ease of operation and quality of musical performance, were made by Theobald Boehm (1794-1881) and Adolphe Sax (1814-1894). Both of these men were proficient performing musicians on the instruments that they designed and constructed as skilled technikers. They designed and made new instruments with new materials, new sizes and shapes, new hole and key arrangements--that required new fingerings, and then played the new instruments to prove to themselves that worthwhile improvements had or had not been made. Through the efforts of these and other designer-users we now have musical instruments that are satisfactory enough to be standardized for mass production. The standardization and resultant low-cost production have facilitated the teaching of instrumental music, and increased the availability and enjoyment of musical culture in general.

The conclusion to be drawn, without citing more examples, is that design of equipment proceeds best when designers have not only the necessary technical ability and financial resources, but have also,

1) a <u>personal</u> feel for the user's needs, and

2) <u>personal</u> experience in realistic use of the equipment.

When designers use equipment under real operating conditions they maximize the impact that equipment shortcomings should have on the designer, and minimize the difficulty of communication between user and designer.

Second-best for design of equipment is cooperative, common-objective work by a designer and user on a person-to-person basis--preferably on a first-name basis. Such an effort is exemplified by the joint efforts of the designer Frédéric Triébert and the oboe player-teacher Barret, in the 1860's, in improving the oboe. Another type of cooperation occurred in 1824 when the designer-player Carl Almenraeder worked with the physicist G. Weber in revising the holes and keys of the bassoon in order to achieve more positive and uniform response from the instrument.

Going a step beyond the design of musical instruments to the design of music itself, there is the outstanding example of Mozart's concertos. The concertos display his remarkable understanding of the rich artistic and technical natures of the different solo instruments. Mozart's understanding of the instruments came from his own technical ability at the piano keyboard and from his working friendships with top-notch professional musicians, such as the

horn player, Leutgeb, and the clarinetist, Stadler. The concertos are testimonials to the potency of active personal involvement and interplay, with mutual determination to get full benefit from equipment, in generating culture.

Some of the human side of the relationship between an advanced culture, an equipment user, and (by implication) an equipment designer is contained in the response that a contemporary clarinet soloist made to a reporter who asked him, "Which of the different woodwinds is the most difficult to play?" The soloist pondered a moment and then said, "Music is a hard instrument."

There are some obvious advantages to having high-caliber specialists, including teachers who specialize in a particular era of European history, and technikers who specialize in nuclear magnetic resonance. One great disadvantage, however, is that different kinds of specialists, even in the same general field, find it difficult to converse and cooperate understandingly with each other. The disadvantage becomes even greater when specialists are asked to go outside of their general field.

As it is now, competent and well-intentioned designers of instructional equipment can become so absorbed in working

on some technically fascinating mechanism that they neglect to find out what the user most wants improved. Also, competent and well-intentioned teachers can become so preoccupied with presenting, in their own present fashion, the things that fascinate them that they neglect to find out how they can best use, and help improve, instructional equipment for the benefit of both learner and teacher.

This situation is similar to one that was experienced by a non-citizen of this country who had the misfortune to lose his passport as he was motoring through New England on his way to Canada. At the border, he was told that telegraphic confirmation of the existence of the passport would satisfy border officials. The telegraphic confirmation was obtained, and he took it to one of the two border-official houses, which faced each other across a street in the little border town. The officials looked at the telegram and said, in friendly fashion, that all that was necessary now was to get one of the other officials to walk across the street to agree with them in person. The officials across the street said the same thing, just as amiably. Neither side budged.

That episode is presented here in order to underscore

the following recommendation: an agency outside the instructional and techniker professions should take the opportunity to be prime mover in establishing several teams of carefully selected teachers and designers devoted to improving the design and use of instructional equipment. Not the design alone. Not the use alone.

Recommendation (see previous paragraph)

The prime-mover agency should be unbiased and impartial, in order to be respected by all the team members. It should sponsor the work on a long-term continuing basis, keeping in mind that the results will appear and be accepted as parts of an evolutionary, not revolutionary process. It should avoid premature publicity. Well-established results should be well publicized, of course, with due reference to the identity of the prime-mover agency.

The schools and teachers for the project teams should be chosen very carefully. High schools seem to be particularly suitable for meaningful trials of instructional techniques and equipment. A good starting point for the selection process would be for prime-mover agency representatives to have discussions with some high-school principals, and follow through in appropriate schools to interview teachers

recommended by the principals. The teachers chosen for the initial projects should be not only top-notch teachers, based on current performance, but very articulate and willing to respond candidly and constructively to questions about why a certain topic or course is presented in a certain way. They should be willing, also, to conceive and develop other ways.

In order to have time available for the project, the chosen teachers should be relieved of the teaching of at least one class a day during the regular school year. In the summer they should be completely free and willing to devote full time to the project. Because the project requires sustained extra effort by the teacher, he certainly should be paid for that extra effort.

Obviously, the designers should also be chosen very carefully. They should be creative, versatile members of, or have regular working contact with, relatively large interdisciplinary groups of technikers. The "relatively large and interdisciplinary" are stressed because the technical solutions to the design problems should use the best technology available, without being biased toward a particular technical approach. An appropriate starting point is for prime-mover

agency representatives to have personal discussions with heads of sizable, broad-scope, economically minded, techniker research and development groups, followed by interviews with recommended designer-technikers. A chosen designer should be adept at getting other technikers to add their knowledge and inventiveness to his, in order to get "the best of all possible technical solutions" to the user's problems. He must, of course, be willing to spend a lot of his time in the classroom, getting familiar with the user's needs by being a vicarious teacher and learner. Therefore, he must be personally acceptable to the teacher and the learners.

The people in the project teams and prime-mover agency must have patience as well as dedicated diligence. Most of the projects will proceed relatively slowly, by trial-and-error experimentation. The designer must start in the classroom to get acquainted with the users and their problems, and start building a conversational road between learner, teacher, and techniker for effective communication about the major problems. When the designer returns to his workplace, the teacher should visit him there on occasion, to help widen and smooth that conversational road by getting better acquainted with the designer, his environment, and resources. After the first

equipment has been constructed, it should be subjected to critical test in the classroom, with the designer present (preferably operating the equipment part of the time), then returned to the realm of the technikers for modification, and so on through a number of cycles.

There are other facets of the basic recommendation that deserve discussion. All of the facets, however, are matters for the agency, administrators, and team members to develop and resolve.

At this point, the recommendation is concluded with an earnest plea to officials of foundations and government agencies, particularly those in the department of Health, Education, and Welfare. A plea that they seize the opportunity to make substantial increases in our cultural wealth by being prime movers of select project teams devoted to improving the design and use of instructional equipment.

A Common Objective

Teachers and technikers in the proposed project teams have the common objective of increasing the quality and quantity of cultureal information acquired by the learner. Information is used here to mean that which is significant to the particular learner. It does not include any and all

messages, because some messages are incomprehensible or of no consequence to certain learners.

Technikers speak of messages as being sent in the form of signals. They speak also of signal-to-noise ratio--a measure of the quality of the received signal. Noise is exemplified by the scratchy sounds that attended the music in old-time shellac phonograph records. In modern records the signal-to-noise ratio is a million to one. The techniker speaks of that ratio as being sixty decibels. To some technikers, sixty decibels is information. To non-technical teachers, however, sixty decibels is just a noise. In a bygone ear, Ambrose Bierce said, "Noise is a stench in the ear." In video displays, noise can also be a stench in the eye. An example of video noise is illegible scrawling on a chalkboard. Technikers are continuing to increase their already great proficiency in sending, storing, and reproducing signals which, when received, are strong and clear.

Technikers are also becoming increasingly adept in processing enormous quantities of signals in short times. Millions of signals a second are already a commonplace in some parts of the techniker art. There is no point, however, in sending millions of signals a second to a learner. His

signal-receiving capacity is limited, as was previously mentioned, and when that capacity is greatly overloaded it essentially breaks down, with the result that the learner gets nothing but noise out of the surfeit of signals.

In the project teams, teachers and technikers alike will be concerned with maximizing the information-to-noise ratio, keeping in mind that signals received by an uncomprehending student are, at best, noise; at worst, they can negate information previously imparted. From the project teams there will come instructional equipment to help individual teachers and learners increase their information-to-noise ratio. From the teacher's standpoint, they want and should have equipment that is quickly accessible, versatile, flexible, reliable, and under their control. They know that a class will "cluster," with some students at one educational level, others at another level, etc. Each level requires different treatment, with educational content and pace suited to each "cluster." Class discipline as well as educational efficiency are at stake.

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THE DESIGN OF INSTRUCTIONAL EQUIPMENT: II[1]

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With effectiveness of audio-visual materials definitely established, more research effort now needs to be directed toward incorporating instructional technology in the classroom on a scale commensurate with the potential. It is the purpose of this paper to examine some of the relationships which have existed between leaders in education, equipment manufacturers and enterprises which supply the content carriers (films, etc.), to see whether it is possible to suggest improvements in what is acknowledged to be a slow and cumbersome process of bringing new products and concepts from the researcher to the schools.

Historically, we find a pattern in which new devices for communication have been developed outside the school field, and have then been adapted to, and adopted by, the schools. This is demonstrably a slow process. However, materials have

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[1]Originally submitted by Mr. Townsley under the title, "Developmental Patterns in Audio-Visual Equipment."

been produced specifically for the schools with varying degrees of participation by educators.

There are fields aside from the schools in which it is necessary to communicate with people under somewhat analogous teaching-learning situations. Our economy requires us to communicate the virtues and operating methods of a new product, or to train people to sell telephones or to repair automobiles, as well as to teach the Pythagorean Theorem. This means that the industrial field has some opportunities to experiment with communications devices in situations where chances to get a quantitative measure of the effectiveness of equipment and technique are excellent. Many of these programs can be designed to produce results measurable in dollars. In addition, application of learning is quite immediate, so that the experiment has a finite period.

The inertia of the school field is an important reason why new techniques find broad application in other markets before they make a mass invasion of the schools. This inertia causes the manufacturer to look to other markets for initial exploitation of any new device or concept, in order to recover his development and tooling costs as soon as possible. This may be of positive advantage to the schools, because it offers

an opportunity to shake down the device to improve its performance and reduce its cost. This process does allow broad exposure to the public with a consequent grace period to study the special needs of school use and make modification, if necessary. It is during this "pre-school" time that the equipment becomes standardized as to features, performance, and durability. Dimension and form are agreed upon so that materials are interchangeable in equipment of several makers. Production is limited to a few models in large enough volume to lower manufacturing costs.

Manufacturers traditionally have had difficulty in learning what the school market really wants. During the Princeton Conference on New Media, Dr. Robert M. Hayes described this market as being "clumped." There are too few discrete units to be handled statistically as can usually be done in a consumer market, and too many to be considered as individuals. Within this clumped framework, the school market is also a very diverse one, with mutually exclusive ideas very strongly held in different parts of the field and with poor communication between the clumps.

In this kind of environment, the spread of a genuinely new concept in teaching is necessarily slow. It must be

tried out on a small scale, revised, and refined. Then there usually must be controlled experiments to demonstrate that some particular piece of teaching can be better done under the new concept, and the facts of this demonstration must be communicated to other researchers for validation, and finally to the schools who will eventually have to purchase the resulting equipment and materials.

Virtually complete local autonomy in management and control of schools is one of the strengths of our educational system. It guarantees that a new idea will be well tried before it can be exposed to curriculum planners, incorporated into the courses of study, budgeted, and finally delivered into the schools for use. On the other hand it is a source of massive inertia to technological innovation, especially that relating to research and development leading to new instructional equipment. Some sort of screening and refining process seems very important. We may get concepts reduced to the "lowest common factor" and thus emasculated, but who is to say that some super-authority charged with the development of new educational systems could do better. In the light of our experience, it is difficult to believe that such an authority could be so omniscient as to secure the development of the very best

techniques. It seems more likely that there is strength in the refinement of ideas through exposure to many minds, and that indeed, "all of us are smarter than any of us."

There are new factors which are beginning to make themselves felt in the development of new media of instruction. We have already said that education has acknowledged the possibilities and some of the needs, and is beginning to search for further advances. There is a new receptivity for teaching methods and devices, and a lessening of the fear that they will replace teachers entirely. A new conceptual tool called "Systems Engineering," which has come out of highly complex military-industrial problems, is making itself felt, so that there is an increasing ability to look at the whole problem of education and to fit the elements into a system, rather than looking at each development in isolation. Money, interest, and guidance are becoming available from many sources. Agencies of the federal government and private agencies national in scope have been committed to exploring the new media, and have sponsored major programs in their application on a very large scale. The Ford Foundation has given major sponsorship to experimental development of television instruction through programs like the Hagerstown installation and the Midwest Program on Airborne

Television, providing a massive workshop for the evaluation of television as an educational tool. The technical inventors of television and the manufacturers of television equipment, from the very first, have thought of television as a potential educational force, but the massive development cost had to be borne by commercial and entertainment applications so that there could be a television industry which could serve education with equipment and programming techniques especially adapted to educational needs.

The U.S. Congress, under the National Defense Education Act, has provided funds and backing for a great deal of pioneering experimentation in new media and has provided matching funds for purchase of audio-visual materials and devices by schools. Availability of NDEA money probably has hastened wide scale introduction of language laboratories into the public schools. Demonstration of the language laboratory as an effective teaching tool, recognition of the need for rapid expansion of language teaching, a total change in the concept of teaching languages, and a dearth of qualified teachers combined to mushroom the growth of language laboratories in the schools.

As the schools become aware of the opportunities for

better teaching with the new media, and as money becomes available from national and local sources, manufacturers have become much more active in seeking opportunities in the school market. Some teaching tools have sold well enough over the years to demonstrate that, once a tool is accepted, there is a worth-while market. It is estimated, for example, that about 150,000 sound motion picture projectors are in use in the schools, with new sales running over ten per cent of this figure each year. Strip-film projectors total 1/3 more than this figure.

With this awareness of the market and with a strong public service motive, the manufacturers are beginning to follow the lead of the educational publishers in seeking out innovators in educational research so that they can assist in adapting the available or new product to the educational process. The educational researchers are themselves improving their communications techniques. Some of them are becoming very adept at attracting the attention of eager manufacturers and of the U.S. Office of Education so that projects get support and public exposure. It may be that improvement in communication may be a more important contribution of the work on teaching machines than are teaching machines themselves!

One result of the new sophistication in communication between educators, research workers and supporting industries is the application of electronics techniques to the simulation of teaching systems. Space Technology Laboratories, for example, has programmed a large computer controlling television consoles to simulate audio-visual teaching systems of very great flexibility. It seems unlikely that we will see wide scale use of so sophisticated a system for direct teaching for many years, but it is the hope of those on the project that by having so flexible a research tool, something will be discovered about the learning process which may lead to the development of new media.

None of these things change the basic stages through which new media are developed. All we can hope for is to improve coordination between academic needs and hardware possibilities so that good ideas come through into general use as quickly as possible, while bad ones get weeded out with a minimum of economic loss. But the cylcle is still the same.

Nothing much can happen until a valid educational concept meets a commercially practical device for its implementation. Most such meetings are evolutionary, rather than revolutionary. A tentative educational concept meets a tentative mechanical

possibility and one is used to help validate the other. Validation must proceed from both ends of the scale. It is as useless to have an educational concept which requires devices clearly beyond the means of the schools as it is to have the simplest and most economical device which does nothing to help learning. More and more in recent times, developers of new communications devices are carefully examining their products to see whether they can detect an educational application, and are seeking out educational researchers for validation of these applications. At the same time, the process of getting a new device into the schools is so long that the instructional values of new developments are very likely to be first exploited in more commercial fields such as industrial or military training before attaining wide acceptance in the schools. As we have already said, this helps to give the schools a standardized and seasoned product when it finally reaches them.

The effort and the money required to develop new materials may well be as great as that required to develop the devices themselves. This material must of necessity be developed by those competent to select the content to be taught and to organize it for most effective teaching. When it must, for presentation, be adapted to a specific device, the job is

even bigger. Publishers and motion picture producers have established standards for the production of materials in their respective forms. As newer forms of material are developed, there must be new channels to perform these same "publishing" functions. Publishers and film producers, as the longest established organizations in the field, are aware of standardization problems, and at least some of them are moving to solve them. At the same time, some of the equipment manufacturers are moving into closer relationships with publisehrs and "authors" so that equipment needs are taken into account in the whole process.

The communication flow between educator, educational researcher, author, "publisher" of content materials, and manufacturer of devices may well center about the clear concept of the teaching job to be done; the change in knowledge, skill, or behavior which is to be elicited in the student. This is the central core of the teaching job. Growing out of it are the specific tasks of the various groups who bring their skills and resources to bear. The content of the teaching material and its organization are the responsibility of the educator and the "author." They also must select the form to communicate the content most effectively to the pupil.

Someone, usually an educator close to the classroom, must select or plan the environment in which the attempt to communicate takes place. The group size, their physical surroundings, their previous experiences, are all important parts of this environment. If a specific method of presentation is selected, there should be specific environmental conditions under which it is most effective. Books are essentially a medium for individual use, requiring adequate light and minimum distraction. Films, tapes, lectures, set their own requirements. One of the communications problems is to find a way for the manufacturer of devices and those who provide the environment to agree on requirments and their relative importances. A milestone in this direction may be the recent organization of the committee on projection of the Technical Equipment Commission of the Department of Audiovisual Instruction, which has charged itself with the task of attempting to work from the teaching job to define the environment and the functions of motion picture projection.

There is a great deal of evidence, then, that the pattern is accelerating as closer contacts are developed and a new awareness grows of the needs and potentialities which exist in the educational field. New content with important needs and concurrent teacher education problems are having a strong

influence on the use of new media of instruction. The availability of special money for the specific purpose of attacking these needs is stimulating both needed contact and research in teaching and communication. Some of this money is going directly to the development of new devices, although by far the bulk is being directed, as it should be, to the more fundamental problems of content and organization.

The pattern seems to point to even closer contact between the educational researcher and the manufacturer of devices, perhaps parallel to that between author and publisher, with the manufacturer perhaps playing a larger role in the communication between the researcher and the schools.

Educational researchers need to recognize more generally than they perhaps do that industrial and commercial training programs involve teaching, too, and can provide important opportunities to validate new teaching concepts while their faster commercial reaction to new ideas can make them important and self-supporting experimental laboratories for educational research and for the development of new media.

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